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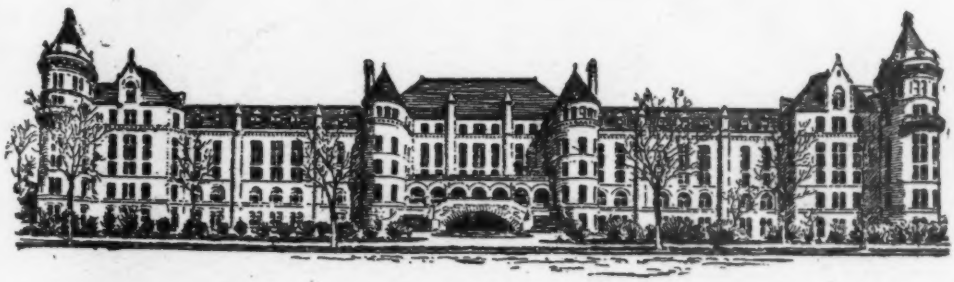
THE AMERICAN MUSEUM JOURNAL



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THE AMERICAN MUSEUM OF NATURAL HISTORY was established in 1869 to promote the Natural Sciences and to diffuse a general knowledge of them among the people, and it is in cordial coöperation with all similar institutions throughout the world. The Museum authorities are dependent upon private subscriptions and the dues from members for procuring needed additions to the collections and for carrying on explorations in America and other parts of the world.

The membership fees are,

Annual Members.....	$ 10	Fellows..	$ 500
Life Members	100	Patrons	1000

All money received from membership fees is used for increasing the collections, and for developing the educational work of the Museum.

The Museum is open free to the public on Wednesdays, Thursdays, Fridays, Saturdays, and Sundays. Admittance is free to Members every day.

THE CHILEAN MUMMY

Naturally Mummified Body found in a copper mine at Chuquicamata, Chile.

The American Museum Journal

VOL. VI. JANUARY, 1906. No. 1

THE chief feature of the current number of the JOURNAL is an article by Dr. B. E. Dahlgren, of the scientific staff of the Museum, describing the development of a mollusk and forming a guide to the series of models which he has prepared to illustrate the development from the egg to the adult stage of the little shell known to the conchologist as *Crepidula*. This shell occurs in great numbers along the North Atlantic coast and is commonly known in the United States as the "Boat Shell," on account of its shape and the diaphragm in it which resembles the thwart of a boat. In Great Britain the same shell is called the "Slipper Limpet." This article is also published separately as No. 21 of the Museum series of Guide Leaflets and may be obtained at a nominal price.

A NATURALLY MUMMIFIED BODY FROM CHILE.

ONE of the most remarkable specimens that the Department of Ethnology has acquired in years was obtained by the Museum in November. It is a naturally mummified body which was found in a copper mine at Chuquicamata, province of Antofagasta, Chile. The condition of the body shows that the unfortunate miner, probably a woman, was caught by a cave-in of the roof and partly crushed. The mummification seems to have been produced in part by the action of copper salts and not to have been merely a desiccation due to the dryness of the region. The skin has not collapsed on the bones, as in the mummies found usually in the region, but the body and limbs preserve nearly their natural size and proportions, except for the crushing already mentioned. No analysis has yet been made of the tissues, so that it is too early to hazard any supposition as to

the chemical changes which have been undergone. The mine has been worked for an unknown length of time upon a peculiar deposit of atacamite, a hydrous chloride of copper, which is much prized on account of its easy reduction. The age of the mummy is unknown, but it is supposed to be pre-Columbian.

THE SERIES OF ETHNOLOGICAL BUSTS.

THE model of the bust, or rather the head and neck, of the young Filipino, illustrated on page 5, is one of an extensive series of typical portrait busts which the Museum has been assembling during the past eight years. The basis of the model is a mold, or mask, of the face taken from a living subject. The Museum now has more than five hundred such molds, together with the additional data necessary for producing the busts. A large number of complete busts has already been prepared. They are in use for study and for exhibition in the Museum and are in constant demand for exchange with other institutions.

The greater part of the molds represent typical individuals of the North American tribes: the Indians of the Eastern Woodlands, the Plains and Pueblo districts, California, the Pacific Coast and the Eskimo of the Arctic regions. Of Asiatic peoples the Aino, Chinese, Japanese and several Siberian tribes are well represented. Molds from the Philippine, African and South American native tribes who were at the St. Louis exposition are recent additions to the series.

It is the purpose of the Department of Ethnology to make a collection in which all the physical types of man shall be represented For many years the value of a collection of skulls from the different races has been appreciated, but the experience of investigators is that skulls alone give inadequate data for the study of a race, since differences in the form and size of the skull are not correlated with variations in the size and form of the head. The ideal method of studying the facial characteristics of a race is by means of direct measurement of living subjects. Since, however, such subjects are not always available, and an

CLAY BUST OF FILIPINO YOUTH

Modeled at the American Museum of Natural History by Caspar Mayer.

opportunity for repeating measurements is not often offered, properly prepared molds of faces provide the ethnologist with a reliable record upon which to base his investigations.

The task of making the molds from life and preparing the modeled busts for the Museum series was placed in the hands of Mr. Caspar Mayer, under the direction of the curators of the Department of Ethnology Mr. Mayer has greatly improved the old methods and has devised new processes for taking life-masks and utilizing them in connection with photographs and measurements for the rapid production of busts which represent with reasonable accuracy the individuals treated.

THE COLLECTIONS ILLUSTRATING THE ROCKS AND MINERALS OF MANHATTAN ISLAND.

THOSE who are interested in local geology and mineralogy will find much to repay careful study in two collections which are on exhibition in the Museum : the rocks of Manhattan Island at the north end of the Hall of Geology, and the loan collection of the New York Mineralogical Club, comprising an almost complete series of the minerals of the island, which is on exhibition in Case 27 in the Morgan Mineral Hall. In addition to the collections on exhibition, there is a large study collection of the rocks which were encountered in the excavation of the Subway.

The foundation of Manhattan Island consists entirely of crystalline rocks: gneiss, mica, schist, hornblende schist, serpentine and magnesian limestone (dolomite). Cutting through the gneiss and schist there are countless veins and dikes of granite and pegmatite, and these have supplied most of the minerals for which the island is noted. The crystalline rocks have been covered with a mantle of Glacial Drift (unstratified gravel, sand and clay) of varying thickness, while below Fourteenth Street there are extensive river deposits of stratified gravel, sand and clay among bosses of rock (schist) most of which were below the ancient water-level.

The major portion of the island consists of the gneiss and

schists, the general trend ("strike") of which is N.N.E.–S.S.W. These rocks can be studied in almost every excavation for building purposes, and there are numerous excellent exposures of them, which fortunately will never be covered, in Central, Riverside and Morningside Parks and along the Speedway and

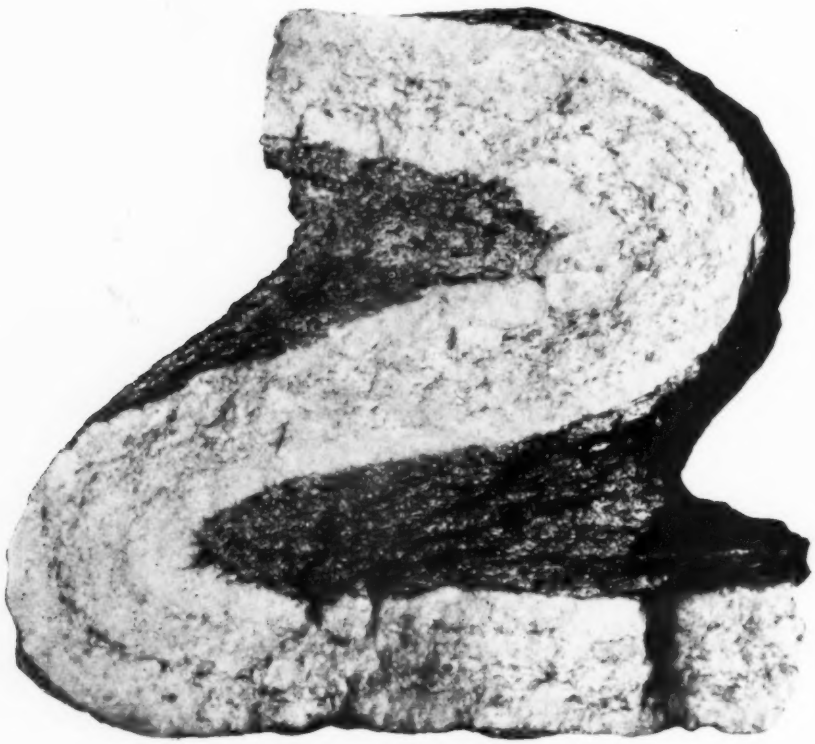
MICACEOUS GNEISS

A block of Fordham Gneiss (Archæan) from the east end of Washington Bridge, N. Y. Closely resembles the gneiss of Manhattan Island. Specimen is 20 inches across.

Lafayette Boulevard. The area of serpentine is very small and is now inaccessible on account of buildings. It is at Tenth Avenue and West Fifty-eighth Street. The magnesian limestone, or dolomite, occurs in zones in Harlem, where it is now almost covered with buildings, and in the Kingsbridge section of the island, where a good exposure may be seen along the Spuyten Duyvil ship-canal.

The exact distribution of these rocks can best be learned from a study of the geological map of New York City and vicinity

which has been placed beside the local rock collection in the Hall of Geology. The collection has been arranged in two cases. One of these shows the kinds of rocks encountered when crossing the island from east to west at several points, while the other shows nearly all the varieties of rock which have been found in ledges on Manhattan Island. Three sections of borings, further-



QUARTZOSE VEIN IN MICACEOUS GNEISS

West End Avenue near Sixty-third Street. Specimen is 5½ inches across.

more, show the rock found at considerable depths at widely separated points, and prove that there is no change from the surface.

The mica schists and gneisses are now considered by geologists to be shales and other clayey rocks of Hudson River (Lower Silurian) age which have been altered to their present crystalline

condition by heat and pressure combined with motion. The crystalline limestone, which is almost a marble in some beds, is much older, geologically speaking. Its present condition is due to the severe metamorphism which it has undergone in company with the schists. The hornblende schists are considered to be of igneous origin, which would indicate that this region experienced volcanic activity millions of years ago. These schists occur in comparatively small detached areas and are the highly metamorphosed representatives of the molten lava, which was forced into cracks in the old sedimentaries and solidified in the form of trap dikes or was poured out upon the ancient surface in sheets. The hornblende schist may be distinguished from the inclosing mica schist by its darker color, due to the abundance of black hornblende. Actinolite and tremolite schists occur in company with some of the hornblende schists. East of the Harlem River and north of Spuyten Duyvil Creek there is a gneiss resembling some of the Manhattan Island gneiss in appearance, which is older than that and antedates even the magnesian limestone.

The minerals of Manhattan Island are, for the most part, silicates of complex chemical composition, and they vary with the nature of the rock with which they are associated. It is comparatively easy, therefore, to group them according to their occurrence into the minerals of (*a*) the gneisses and mica schists, (*b*) the hornblende schists, (*c*) the granite and pegmatite veins and dikes, (*d*) the limestone beds and (*e*) the serpentine area, and this subdivision has been followed in the arrangement of the collection. In connection with the study of the specimens the visitor will do well to consult the geological map of New York and vicinity attached to the case and the chart showing the distribution of mineral localities on Manhattan Island which has been placed in the case. The chart is reproduced herewith.

The minerals of the gneisses and schists are primarily quartz, feldspar and mica, the last predominating. In this association these minerals rarely occur upon Manhattan Island as handsome cabinet specimens, but there occur with them, as secondary effects of the metamorphism of the original beds, fibrolite, epidote and other species. Crevices in the schists have given

opportunity for the formation from circulating waters of interesting little globules of sphærosiderite and several members of the group of zeolites, such as heulandite, harmotome, stilbite and chabazite. The stilbite occurs in noteworthy rosettes of slender, blade-like yellowish brown crystals upon the surface of the rock. These zeolites are particularly interesting for study in comparison with the remarkable specimens of the same species which have come from the cavities in the trap rock (diabase) of the neighboring Palisades.

The chief cabinet mineral of the hornblende schists is sphene, which occurs in showy groups of yellowish green, flattened crystals. The principal constituent of the schists, however, is black hornblende, which occurs in needle-like crystals. Epidote too and actinolite are often found in this rock. Exposures may be seen in Morningside Park and the Fort Washington Heights section of the city, but most other localities have been covered with buildings or streets.

The granite and pegmatite veins or dikes are the principal contributors to the local mineral collection. The origin of these rocks is still a mooted point, but probably some of them are acid igneous intrusions, while others, particularly the pegmatites (characterized by their coarseness of crystallization), are the result of chemical precipitation from circulating waters. First to be mentioned are orthoclase, microline, oligoclase and albite among the feldspars; muscovite and biotite among the micas, and quartz. Garnets of small size are scattered all through the schists, but gigantic crystals of this mineral have been found in the pegmatite veins, the largest of which came from an excavation in West 35th Street between Broadway and Seventh Avenue. This garnet is a nearly perfect crystal six inches in diameter and weighs nine pounds ten ounces.

Black tourmaline is an abundant constituent of the schists, and it occurs in beautiful crystals in the pegmatites. Sometimes the minute, flattened crystals imbedded between plates of muscovite have been mistaken for the rare mineral dumortierite. Large crystals too have been found. An imperfect one, twelve inches long and five inches across, is in the Club collection, while a crystal of almost ideal development, about ten inches long and

SKETCH MAP OF MANHATTAN ISLAND

The dots indicate the situation of the principal mineral localities.

four inches in diameter, from near Fort Washington Avenue and 171st Street, is in the general Museum series.

Among other species which have been found in the granite and pegmatite veins mention may be made of allanite in the form of the long, lath-like crystals known as orthite, apatite, beryl, cyanite, dumortierite, iolite, monazite, ripidolite, wernerite, xenotime and zircon. Monazite is a compound of the rare elements cerium, lanthanum and didymium with phosphoric acid, and is the source whence the impregnating substance for the mantles of incandescent gas lights is obtained. Uraninite, or pitchblende, the chief source of radium, occurs on the island. Galena, the sulphide of lead, has been found in minute crystals on crystals of chabazite. Gypsum in radiating crystals on mica schist is one of the oddities of the collection, and fluorite (from the Subway) is another. Chrysoberyl, too, has been found in one locality. Azurite and malachite occur rarely on the island.

The limestone beds have furnished the collection with malacolite (white pyroxene), brown tourmaline and pretty groups of crystals of smoky quartz. Fibrous aragonite has been taken from thin veins in the limestone.

Finally, the serpentine area yields an intimate mixture of calcite and serpentine resembling the spotted green and white rock called ophio-calcite. Large specimens of this peculiar rock may be seen in the local rock collection in the Hall of Geology. At one time this mixture aroused considerable interest from the erroneous supposition that it corresponded with the famous Canadian "fossil" of Archæan age, *Eozoön Canadense*.

A complete list of the minerals of Manhattan Island would include the names of nearly one hundred species and varieties, and the region has been one of the most prolific in kinds in the world. Although most of the ground is now inaccessible, that which remains offers inducement to the diligent collector to search for mineral treasures to add to his cabinet.

EDMUND OTIS HOVEY.

MR. CHARLES B. CROOK has presented the Museum with an elaborate feathered head-dress, once worn by an East African chieftain.

DEPARTMENT OF VERTEBRATE PALÆONTOLOGY, EXPLORATIONS OF 1905.

THREE parties were sent into the field by the Department of Vertebrate Palæontology during the past summer. They carried on explorations and excavations in Montana, in central Wyoming and in southern Wyoming.

The party in southern Wyoming under Mr. Walter Granger went out especially in search of remains of the animals which lived in the Middle Eocene period in the region around the now abandoned military post of Fort Bridger. This classic locality has been explored from time to time since 1870, particularly large collections having been secured by Professor Marsh of the Yale Museum, by Professor Cope and by the Princeton Museum. American Museum exploring parties visited the region in 1893 and 1895 and again every season from 1903 to 1905, always seeking for remains of the so-called "mountain horse," or *Orohippus* of Marsh, an important stage in the development of American horses. After these six years of the most painstaking search, which were rewarded by the discovery of a great variety of other animals but by few or no remains of the horses, on the very last day of the final expedition, just as the search was being given up, the long-looked-for horse was discovered, the find consisting of the skull, limbs, backbone and other parts of the skeleton of the very stage which was needed to fit into the remarkable series which the Museum has been bringing together. Other valuable specimens were secured besides the "mountain horse." The most important of these were a nearly complete skeleton of one of the large carnivores of the period, a nearly complete skeleton and the skull of the running rhinoceros of the period, *Hyrachyus*, an unusually perfect skeleton of a rodent and a skull which may prove to be that of one of the Bridger monkeys. The staff of the expedition included Messrs. Miller of this Museum and Sinclair of the Museum of Zoölogy at Princeton.

The work of this season completes the very thorough survey of the ancient Bridger basin to which this Museum has now de-

voted six arduous years, beginning with the explorations of Dr. Wortman and ending with those of Mr. Granger. As a result of this work the geology of the basin is now thoroughly understood. It divides into a series of great steps or substages, each of which is distinguished by its own peculiar forms of life or of specific stages. Only in the upper stages do the great horned Uintatheres appear for the first time. During the season of 1904 the Museum secured the most complete skeleton thus far found of a Uintatherium, including the fore and hind limbs. This will now be mounted with the aid of certain portions of the type specimen of *Dinoceras mirabile* in the Yale Museum.

The party sent to central Wyoming under Mr. Peter Kaisen had a somewhat similar experience. They were exploring the "Bone Cabin" dinosaur quarry which has yielded such remarkable results during the past seven years. The output this season was in general singularly disappointing, indicating that the quarry was gradually playing out; but at the last a single find was made which repays the entire efforts of the whole season, consisting of the skeleton of one of the smaller Iguanodont dinosaurs remotely related to the famous Iguanodonts which are preserved in the Royal Museum of Brussels from the Bernissart quarries.

The work of this season ends our explorations in the Bone Cabin dinosaur quarry. Together with the fine specimens which have been found in other parts of Wyoming this quarry has given us an almost complete picture of the life of the Jurassic period, so that it has been decided to devote an entire hall to the animals, great and small, of this one stage in the history of the earth. In this hall the most imposing specimen will be the Brontosaurus, already mounted. Near it will be placed the skeleton of the carnivorous Laosaurus, part of the Cope collection presented to the Museum by President Jesup. This skeleton will be mounted in a unique manner upon the prostrate bones of another specimen of Brontosaurus which was found in the Como Bluffs in 1897. Materials are collecting for the mounting of *Diplodocus* and *Camarasaurus* or *Morosaurus*. The Bone Cabin quarry had yielded remains sufficient with some restoration from other skeletons to mount *Stegosaurus* entire. The speci-

mens above mentioned will give us a typical Iguanodont. The small "bird-catching" dinosaur of the period, *Ornitholestes*, is already mounted.

It is proposed to place these skeletons in the central portion of the hall, and in the side cases to exhibit the less complete skeletons and the anatomy of the limbs and other parts of the body, together with diagrams showing the localities in which the famous specimens have been found. It will, however, require several years' work in the laboratory before this exhibit can be completed.

It has not yet been possible to examine either the horse or the Iguanodont skeleton in the Museum, but as soon as they reach the East work will be begun upon them.

The most striking success of the year, however, attended the expedition to Montana. In 1902 Mr. Barnum Brown, who was in charge of this party, found a few remains of a very large carnivorous or flesh-eating dinosaur, imbedded in hard sandstone. The materials which were secured then included a portion of the skull and jaws, a few of the vertebræ of the backbone, part of the hip girdle and portions of the limbs. The fact that they represented such different parts of the body encouraged the hope that further exploration would reveal additional materials. Accordingly instructions were given that clearing and blasting above the locality where the specimen was found should be instituted on a large scale. As a result of this work as the summer wore on the additional remains of this great animal came to light, so that representative portions of the entire body have been secured by the Museum. The animal proves to be of gigantic size, the total length being estimated at 39 feet, the height of the skull above the ground at 19 feet. The new dinosaur is, in fact, the largest carnivorous land animal which has thus far been discovered. In reference to this powerful construction Professor Osborn has given it the name *Tyrannosaurus rex*, or the "king tyrant saurian." It was probably adapted to preying upon the great horned herbivorous dinosaurs of the period, known as Ceratopsia. This remarkable skeleton will be worked out and placed upon exhibition as soon as possible. It will form a worthy companion-piece to the great Brontosaurus.

TWO NEW BIRD GROUPS.

THE most recent additions to the splendid series of groups of North American birds which the Museum owes to the generosity of a number of contributors to a fund designed especially for exhibits of this nature represent the White-crowned Pigeon and the Ani.

The White-crowned Pigeon is a West Indian species which visits the Florida Keys in great numbers to nest in the smaller islets. In the Bahamas it is also migratory, appearing in May and frequenting the same localities year after year.

This Pigeon belongs to the same genus (*Columba*) as our dovecote Pigeon, and it is quite probable that in the warmer parts of the world it could be domesticated.

The flesh of this handsome bird is most palatable, and large numbers are annually killed for food in both the Florida Keys and Bahamas. Unfortunately, this great destruction of life occurs during the nesting season, but the fact that the birds are present only at that time has prevented, in the Bahamas, at least, the passage of laws prohibiting their killing.

The Ani is a species of Cuckoo common throughout the greater part of tropical America and occasionally reaching southern Florida. This bird is exhibited because of its remarkable nesting habits.

It does not mate in pairs, as do most birds, but the four to a dozen or more birds composing a flock live together throughout the year, building a common nest in which all the females lay their eggs. Twenty-one eggs have been found in a single nest, but the number laid by each individual is unknown. All the members of this singular family seem to take part in the duties of incubation and care of the young. The nesting season extends over several months, and fresh eggs may be found in a nest which contains young birds. It appears to be the universal custom of Anis to line their nests with fresh green leaves.

Little has been written about the nesting habits of the White-crowned Pigeon or Ani, and so far as we are aware the groups above-mentioned are unique.

MODELS OF MARTINIQUE AND MT. PELÉ.

THE Department of Geology has recently placed on exhibition a series of models illustrating the Island of Martinique and the effects of the eruptions of Mt. Pelé. There are four models in the series, comprising the whole island upon a scale of 1:80,000, modeled from the chart of the French Admiralty, and three enlarged models of the volcano itself, upon a scale of 1:24,000, or 2,000 feet to the inch, prepared from the same chart and photographic and other data obtained for the Museum in 1902 and 1903 by Dr. E. O. Hovey, Associate Curator of Geology. In all the models the vertical scale is the same as the horizontal. The first of the large-scale models shows the volcano as it was before and at the time of the first great eruption, that of May 8, 1902, which destroyed the city of St. Pierre and its inhabitants. The second large-scale model shows the changes which took place in the volcano in the succeeding months and includes the devastation wrought by the eruption of August 30, 1902. The third large-scale model shows the wonderful spine and cone of lava which was pushed out of the conduit and crater during the winter and spring of 1902 and 1903, the time selected for representation being April 2, 1903, which was at the period of maximum development of the strange structure. The models were prepared at the Museum by the Department of Preparation and Installation. They should be studied in connection with the 118 cases of specimens from Mt. Pelé and the window transparencies.

AMERICAN TUBERCULOSIS EXHIBITION.

FROM November 27 to December 9 one of the exhibition halls of the Museum was placed at the disposal of the National Association for the Study and Prevention of Tuberculosis and the Committee on the Prevention of Tuberculosis of the Charity Organization Society of New York for the purpose of exhibiting the practical work of the Association and the Committee, and demonstrating the methods that have been adopted to limit the spread of a terrible but preventable disease, and to cure persons

already suffering from it. The exposition consisted of exhibits of models, photographs, charts and diagrams from all over the country, and they showed that by far the most and the best work is being done in the city of New York by private as well as public institutions. Models of ward and pavilion tents from various hospitals, an out-door pavilion from Bellevue and photographs showing the treatment at hospitals and dispensaries where special work against tuberculosis is carried on formed an important part of the exposition.

The work of the tenement commission along the lines of preventing the spread of disease by ameliorating the conditions of living was illustrated by models, photographs and statistics. One exhibit consisted of the reproduction of a typical "dark room" in an inside tenement, and of a similar room under the new conditions imposed by the recent law compelling the admittance of daylight to such rooms. Unfortunately there are more than 300,000 such dark rooms still existing in the city. The character of the treatment of tuberculous patients at Saranac Lake, Stonywold and other sanitaria in the State was illustrated by means of photographs.

Great progress has been made at the Clinton State Prison in the treatment of consumption, which is one of the greatest scourges of penal institutions. The model of a ward for consumptives in the Clinton Prison was a feature of the exposition. Outside of New York City and State, Boston and Chicago are the principal cities carrying on a definite campaign against tuberculosis, and much work is being done in Massachusetts outside of Boston and in Maine, Rhode Island, Connecticut, Pennsylvania and Colorado.

The exposition was opened by public exercises in the Museum auditorium at which addresses were made by Talcott Williams, Esq., of Philadelphia, Doctor Thomas Darlington, Commissioner of Health in New York City, and President Morris K. Jesup. On Wednesday evening, November 29, a special meeting devoted to tuberculosis and the trades was held at which the principal address was given by Mr. Graham Taylor of Chicago, and short addresses were made by official delegates from the Central Federated (labor) Union. On Friday evening, December

1, there was a special meeting for physicians at which addresses were made by Dr. Lawrence Flick of Philadelphia, Dr. W. A. Evans of Chicago, Dr. A. Jacobi of New York and Dr. Vincent F. Bowditch of Boston. On Friday evening, December 8, a meeting expressly for the teachers of the public schools was held with the coöperation of the Board of Education of the city of New York, at which the principal address was delivered by Dr. S. A. Knopf of New York.

From here the exposition was transferred to Boston, and from there it is to go to Philadelphia, Chicago and other large cities throughout the country for the enlightenment of the people in the present wide-spread campaign against tuberculosis.

MUSEUM NEWS NOTES.

THE Department of Entomology has received as a gift from William Schaus, Esq., formerly of New York City, a valuable collection of moths embracing some 26,000 specimens, mainly from Mexico, Central America and South America. This collection is the result of about three years of assiduous search, much of which was done under the personal direction of Mr. Schaus, who is a tireless traveler and an enthusiastic entomologist. Four years ago the Museum received from the same gentleman a collection of 5000 butterflies, including many rare specimens from Europe, Asia, Africa, Australia and New Zealand.

THE Department of Ethnology has received as a gift from George S. Bowdoin, Esq., a member of the Board of Trustees, a valuable collection illustrating the fast-disappearing culture of some of the tribes of Central Africa. The collection includes implements of warfare, idols, fetiches and masks, clothing, baskets and musical instruments, household utensils of bamboo, pottery and brass, bracelets, necklaces and household adornments of beads, shells and brass. A large gold bead weighing three ounces and seven carved ivory tusks from Ashantee are worthy of particular mention.

THE Museum has recently acquired a collection of South American pottery containing nearly 200 pieces of black-ware coming from about thirty miles southwest of Supia, Colombia, in the valley of the Cauca River, which is a tributary of the Magdalena. This pottery is washed out and cast aside by the Indian placer miners who wash (sluice) the ancient burial grounds of the valley for the purpose of obtaining the antique gold objects which are frequently found in the graves and which are valued solely for the metal. This pottery is remarkable for its strong modeling, but poor technique. It represents conventionalized forms of armadillos, monkeys, frogs, snakes, spiders, lizards, sloths and other animals indigenous to the region, as well as human figures. Some of the pieces show a strong sense of humor on the part of the maker. The representations of human beings are particularly instructive from the data which they furnish with reference to the use of various personal ornaments and utensils, which have been found in the country.

THE collections of the Department of Geology have been enriched during the past quarter by the accession of considerable material from the Lewis and Clark Exposition at Portland, Oregon. This material includes valuable series of gold, silver and copper ores, oils and other economic products from the State Commissions of Utah, Wyoming, Idaho and California, together with extensive series illustrating the mines of Oregon and Montana and the work which was carried on under the auspices of the U. S. Geological Survey upon the black sands which occur in remarkable abundance along the Pacific coast. These sands have been shown to carry commercially valuable amounts of iron ore (magnetite), monazite and garnet; some of the sands containing also gold and platinum.

THE economic collections of the Museum have received an important loan exhibit in the form of a series of about one hundred samples of peat and the briquettes made from peat, lignite (brown coal) and coal slack. The series was collected by H. H. Wotherspoon, Jr., and was made for the purpose of

showing the commercial possibility of utilizing local supplies of cheap fuel material where the price of good coal is too high to permit its consumption.

THERE has been placed on exhibition a group of Texas rattlesnakes, the material for which was collected by Professor Wheeler and Doctor Dahlgren on a trip to Arizona last spring.

MODELS of two of our commonest and most beautiful forms of colonial Polyzoa have been prepared by Dr. B. E. Dahlgren, assisted by Mr. H. Mueller. Dr. Dahlgren has also completed a model of a rotifer, enlarged about 700 times, which shows one of these microscopic forms of low animal organism. These models are on exhibition in the Synoptic Hall, No. 107, of the ground floor.

THE Department of Mammalogy received in December a series of eight hippopotamus skulls showing various stages of growth from the young to the adult from Lake Ngami, South Africa. The largest of the series represents an animal of about the size of "Caliph" in the Central Park Menagerie. The department has also secured four huge giraffe skulls from Bechuana Land, South Africa. Comparison with the skull of the Museum's mounted giraffe skeleton shows that these newly acquired skulls must have belonged to animals 18 feet high, or half again as large as the mounted specimen on exhibition in the Museum.

THE Philippine wood collection has been removed to the corridor on the ground floor leading from the North Wing to the engine room, where it will be installed in a manner to show to the best advantage the beautiful grains and colors of the specimens. This collection is the most complete that ever has been made, and it represents all the woods of the Philippines which are valuable for manufacturing purposes.

THE annual meeting of the National Association of Audubon Societies, Mr. William Dutcher, President, was held in the Museum, October 31, members being present from Massachusetts, Rhode Island, Connecticut, New York, New Jersey, District of

Columbia, North Carolina and Oregon. The sessions were well attended, and the members were enthusiastic over the sound financial condition and the bright prospects of the Association.

THE Twenty-third Congress of the American Ornithologists' Union was held in the Museum, November 13 to 16, under the presidency of Mr. Charles F. Batchelder. There are now about nine hundred members of the Union, and the attendance at this Congress was greater than at any previous session. Many valuable papers were read, and a feature of the convention was an informal reception in the Museum.

AMERICAN MUSEUM BULLETIN, VOLUME XXI.

DURING the year 1905 the twenty-first volume of the BULLETIN of the Museum has been published. The articles are also published separately and may be obtained at cost prices from the Librarian. The table of contents of the volume is as follows:

LECTURES.

MEMBERS' COURSE.

THE second course of lectures for the season 1905 and 1906 to Members of the American Museum of Natural History and persons holding complimentary tickets given them by Members will be given during February and March. The programme for the course will be issued in January. The lectures will be delivered on Thursday evenings at 8:15 by members of the scientific staff of the Museum and will be fully illustrated by stereopticon views.

PUPILS' COURSE.

THE programme of the first course of lectures to the public school children for the season, was as follows:

	Oct.	Nov.	Dec.	
Monday,	16,	13,	11.	—Mr. G. H. SHERWOOD, "A Tour of Our Philippine Possessions."
Wednesday,	18,	15,	13.	—Mr. H. I. SMITH, "Methods of Transportation—Past and Present."
Friday,	20,	17,	15.	—Prof. M. H. SAVILLE, "A Trip Through Mexico to Panama."
Monday,	23,	20,	18.	—Mr. G. H. PEPPER, "Life Among Our Indians."
Wednesday,	25,	22,	20.	—Mr. F. M. CHAPMAN, "City Bird Life."
Friday,	27,	24,	22.	—Mr. G. H. SHERWOOD, "The Industries of the United States."
			Jan.	
Monday,	30,	27,	8.	—Mr. L. P. GRATACAP, "The Development of New York City."
	Nov.			
Wednesday,	1,	29,	10.	—Dr. E. O. HOVEY, "The Work of Water."

	Nov.	Dec.	Jan.	
Friday,	3,	*	12.—	Mr. R. W. MINER, "Travels Through Western Europe and British Isles."
Monday,	6,	4,	15.—	Dr. E. O. HOVEY, "The Physical Divisions of the United States."
Wednesday,	8,	6,	17.—	Mr. C. W. MEAD, "Our South American Neighbors."
Friday,	10,	8,	19.—	Mr. R. W. MINER, "In the Nile Country."

The second course for the season will be given during the spring months according to a programme which will be announced in February.

These lectures are open to public-school children accompanied by their teachers and to the children of Members on the presentation of their membership tickets. Particulars regarding this course may be learned by addressing the Director of the Museum.

LEGAL HOLIDAY COURSE.

UPON the four principal legal holidays occurring during the winter season the Museum has, for many years, given lectures free to the public, no tickets being required for admittance. The programme for the current season follows. The doors are open at 2.45 P.M., and the lectures begin at 3.15 P.M.:

Thanksgiving Day, November 30, 1905.—PROF. ALBERT S. BICKMORE, "Antwerp, Brussels and Waterloo."

Christmas Day, December 25, 1905.—DR. EDMUND OTIS HOVEY, "Northern Mexico: Its Deserts, Plateaux and Canyons."

New Year's Day, January 1, 1906.—PROF. ALBERT S. BICKMORE, "The Philippines—Manila."

Washington's Birthday, February 22, 1906.—PROF. ALBERT S. BICKMORE, "The Philippines—Luzon."

PEOPLE'S COURSE.

THE second course of Free Lectures to the People, which are given Tuesday and Saturday evenings in coöperation with the Department of Education of the City of New York, will begin in January according to the following programme:

Tuesday evenings at 8 o'clock.

A course of lectures on the geography of Eastern Countries.

* On account of the Thanksgiving holidays the lecture was omitted on December 1.

January 9.—Dr. LEWIS GASTON LEARY, "Jerusalem." Illustrated by stereopticon views.

Three lectures by Mrs. CASSANDRIA A. HAYNES:

January 16.—"To and Fro in Babylon." Illustrated by costumes.

January 23.—"Bedouin Arabs and Things Seen among Them." Illustrated by costumes.

January 30.—"In Reed Encampments." Illustrated by stereopticon views.

Four lectures on Egypt: Life, Religion, Art and Symbolism, by Prof. WALTER SCOTT PERRY, of Pratt Institute. Illustrated by stereopticon views:

February 6.—"The Nile Valley. The City of Cairo. Native Village Life. Agriculture. Mounds and Excavations. Religion, Writing and Symbolism of the Ancient Egyptians."

February 13.—"Ancient Thebes. The Wonderful Temples of Luxor and Karnak. Ceremonies and Festivals. The Temple of Edfu."

February 20.—"Ancient Memphis. The Pyramids. Tombs of the Early and Middle Empires and the Significance of Their Remarkable Decoration."

February 27.—"The Memorial Temples of Thebes. The Tombs of the Kings. Decoration and Symbolism. Sculpture and Ornament. Influence of Egyptian Art."

Saturday evenings at 8 o'clock. All lectures illustrated by stereopticon views.

Three lectures on entomology by Prof. JOHN B. SMITH, of Rutgers College:

January 6.—"Insects and Their Transformations."

January 13.—"Insects in Their Relations to Plant Life."

January 20.—"Insects in Their Relation to Man and to Other Animals."

Five lectures on the solar system by Prof. ROBERT W. PRENTISS:

January 27.—"The Sun: Its Phenomena."

February 3.—"The Sun: Spectrum Analysis, Light and Heat."

February 10.—"The Moon: Its Appearance, Motions, Scenery and Physical Condition."

February 17.—"The Planets: Their Telescopic Appearance and Physical Condition."

February 24.—"Comets and Meteors: Their Mutual Relations."

The lectures of the People's Course are open free to the public and no tickets are required for admittance, except in the case of children, who will be admitted only on presentation of the ticket of a Member of the Museum. The doors are open at 7:30 o'clock and close when the lectures begin.

The programme of the third course of the Public Lectures will be issued by the City Board of Education in February.

MEETINGS OF SOCIETIES.

THE meetings of the various societies that make the Museum their home will be continued until May. Papers on technical and general scientific subjects are read at these meetings. The papers and discussions are often of popular character and are always of considerable general interest. The public is invited to attend the meetings, and Members of the Museum will be provided with programmes on making request of the Director.

The New York Academy of Sciences holds its meetings on Monday evenings at 8:15 o'clock, as follows:

January 8.—Business meeting and section of Geology and Mineralogy.

January 15.—Section of Biology.

January 22.—Section of Astronomy, Physics and Chemistry.

January 29.—Section of Anthropology and Psychology.

For the remainder of the season the Academy will hold its meetings in the following order:

First Mondays.—Business meetings and section of Geology and Mineralogy.

Second Mondays.—Section of Biology.

Third Mondays.—Section of Astronomy, Physics and Chemistry.

Fourth Mondays.—Section of Anthropology and Psychology.

On Tuesday evenings and at other times as announced by the Secretary meetings are held by the New York Linnean Society, the New York Mineralogical Club and the New York Entomological Society.

MODEL 21. FRONT VIEW

The fully formed mollusk larva, or veliger.

THE DEVELOPMENT OF A MOLLUSK.[1]

A GUIDE TO THE SERIES OF MODELS ILLUSTRATING THE DEVELOPMENT OF CREPIDULA.

By B. E. Dahlgren, D.M.D.,
American Museum of Natural History.

Introduction.

THE problem of how living organisms arise must have ever presented itself to the questioning mind. The processes involved in the origin of new individuals nevertheless remained for ages an unsolved mystery. The most familiar example, the origin of the young bird from an egg, cannot have failed to arouse the interest even of primitive man. It must also have furnished the first suggestion towards an explanation. Although undoubtedly long unsuspected, in time it became known that every animal which does not multiply by simple division into two like the very lowest arises from an egg, which is either hatched or developed within the body of the parent. Until a century and a half ago it was generally believed that the egg contained a miniature animal, which became perfected during incubation. Not until the substance called protoplasm had been recognized as the universal "physical basis of life," and, by the aid of the microscope, all living bodies had been found to be composed of cells, was anything like a correct understanding of the nature of the egg and its development attained. The egg was found to be a cell derived like all other cells by the division of a preëxisting cell. Its development, resulting in the formation of the myriad cells of a new individual, was found to proceed by a process of cell-division, essentially similar to that by which growth takes place in the adult.

[1] Issued also in separate form as **Guide Leaflet** No. 21.

Out of the discovery of the character of the egg, of its origin from a parent cell and of its processes of development grew numerous other problems demanding the attention of investigators. Thus the science of embryology came into existence. This science seeks to discover every step in the development of an organism and to trace resemblances and differences of structure and form from their very earliest beginnings. It investigates the conditions which influence development and seeks to discover the factors which determine each step in the formation of an organism, to what extent development is dependent upon external causes and to what extent it is predetermined by the internal organization of the egg. It seeks to determine precisely what this internal organization is and to explain the manner in which the reproductive cell becomes the bearer of the characters of the parents and by what process it is able to transmit these to the offspring.

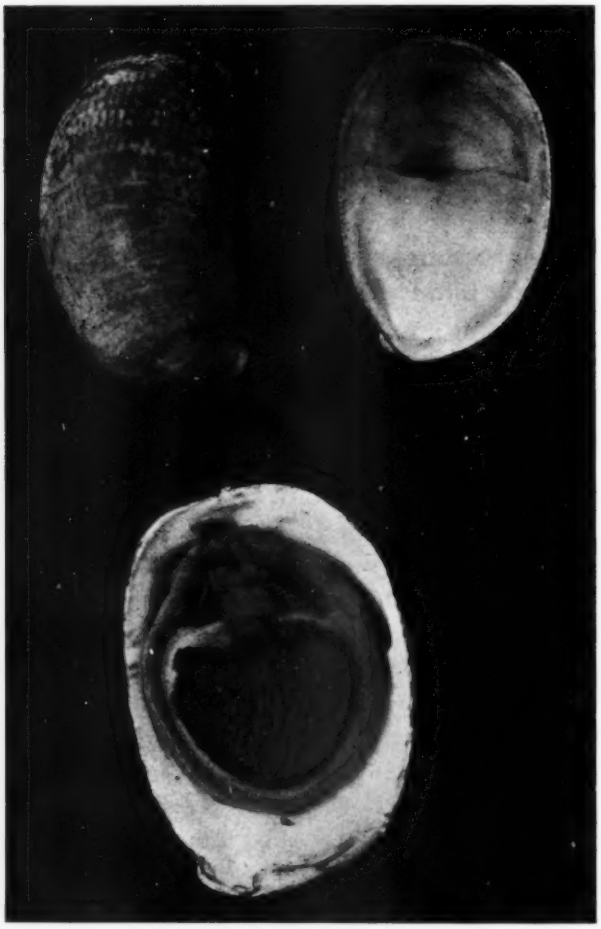
The comparison of the development of different animals soon revealed striking similarities at certain stages. It was found that after cell-division had proceeded to a certain extent the developing egg assumed a form resembling a mulberry (the morula); that later the cells invariably became arranged in the form of a hollow sphere (the blastula), this in turn giving rise to a somewhat more complicated flask-shaped form (the gastrula). It was seen that these various stages presented remarkable correspondences to certain lower forms of life. The analogy of the undivided egg to a simple unicellular protozoan; of the mulberry, or morula, stage to simple aggregations of unicellular animals such as are found among the lowest forms of life; of the blastula to certain Flagellates which occur in the form of hollow, free-swimming, multicellular spheres, and the apparent analogy of the gastrula to certain polyps led to the theory that the developing animal, in the course of its formation from the egg, passes successively through the forms of a whole series of lower organisms which may be considered as its ancestral types.

Formulated at a time when the evolution theory had been recently advanced, this corroborative theory aroused the liveliest interest. Although the original theory has been largely modified since the developmental history of a greater number of

forms has become known, comparisons such as these have thrown much light on the connections existing between various classes of animals, the extent to which developmental histories correspond being, in a degree, an index of relationships.

With a view primarily to increase the embryological evidences of evolution and at the same time to gain a clearer conception of relationships, the development of all the various types began to be traced from the original germ layers. Naturally the conditions which might influence development were considered, and explanations of how the mechanical action of simple physical factors, such as pressure, cohesion and gravity, might tend to cause a dividing egg of a given character to assume successively the various forms through which it passes during development, were soon advanced and received with great enthusiasm. To determine exactly how important a rôle these extrinsic factors play, and the extent to which the future form of an organism is predetermined by the intrinsic character of the egg is evidently of the greatest importance in the solution of the problem of heredity and constitutes at present one of the main problems of embryology .

Although the earlier embryologists were satisfied with simply tracing the origin of the various organs of the body from their primary germ layers which begin to be defined with the gastrula stage, nowadays the solution of the origin of every organ or feature of the body and the significance and factors of every step in development are sought by the most painstaking tracing of the history of every single cell arising by every succeeding division of the egg. It was with a purpose such as this that an elaborate and careful study of the development of *Crepidula* was undertaken by Prof. E. G. Conklin, of the University of Pennsylvania. This study has been followed by the author in constructing for the American Museum of Natural History the series of models described in the present paper.



THE SLIPPER LIMPET OR BOAT SHELL
Crepidula fornicata Lamarck

The Development of Crepidula.

The models represent on a greatly enlarged scale (about 400 diameters) the more important stages in the development of the egg of a gasteropod mollusk of the genus *Crepidula*—the Slipper Limpet, or Boat Shell—common on the coast of the United States. The exceedingly minute eggs (.182 mm. in diameter) are laid in great numbers in capsules secreted by the mollusk. These

capsules, to the number of 50 or 60, each containing about 250 eggs, are united into a grape-like cluster generally found under the shell of the Crepidula attached to the stone or other object upon which it lives its sedentary life. The total number of eggs laid at one time by an animal is about 13,000.

The unfertilized egg (Fig. *a*) is a nearly spherical single cell consisting of a very small amount of protoplasm surrounded by a relatively larger amount of yolk material, mostly in the form of small globules. Within the protoplasm, in a nearly central position, is found the nucleus of the cell. The whole egg is enveloped by a cell membrane.

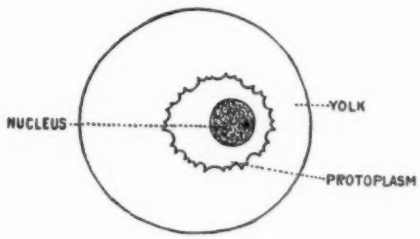


FIG. *a*

The first change which takes place in the egg, preparatory to development, is a migration of the nucleus and protoplasm from a central position toward the upper surface of the egg, the yolk, or deutoplasm, taking its position below it. The egg thus becomes distinctly symmetrical about a vertical axis (Fig. *b*). The upper pole, at which the protoplasm is found, is known as the *animal* pole; the opposite, or lower, as the *vegetative* pole, since

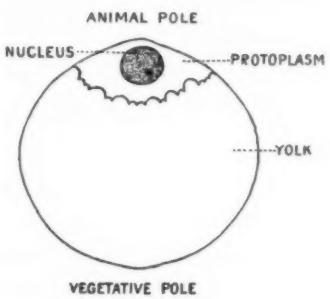
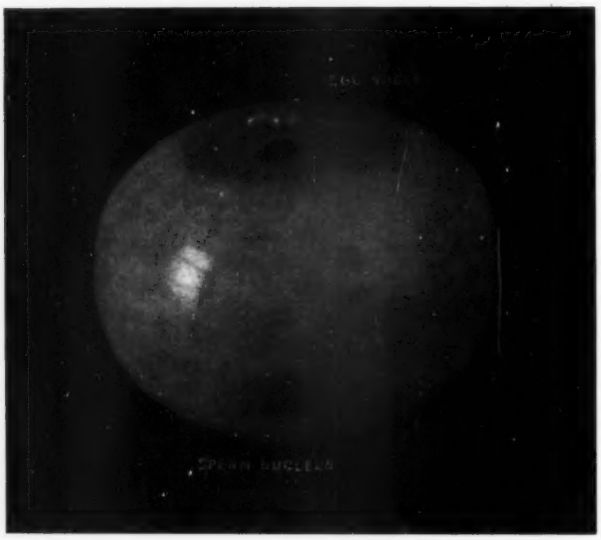


FIG. *b*

about this is collected the yolk or food material contained in the egg. This axis may be followed throughout the development and has been found to correspond to the dorso-ventral axis of the future larva.

About the time of the change in the position of the nucleus and protoplasm, a division of the former takes place. One of the portions resulting from this division, surrounded by a small amount of protoplasm, is extruded at the animal pole, where it remains for a time as a minute body. This is the "first polar



MODEL 1, A

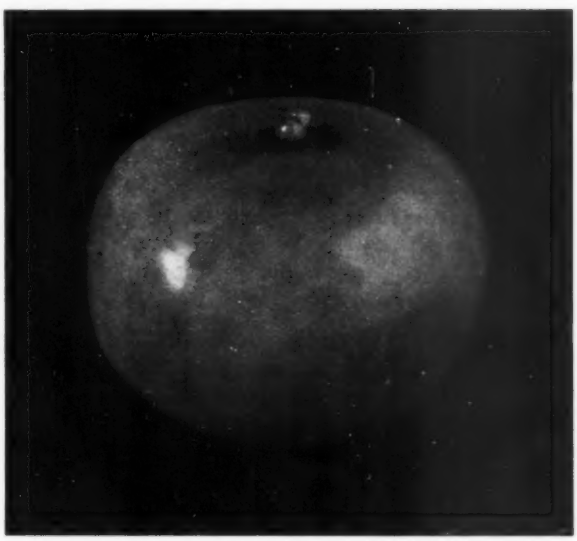
The individual egg showing the clear protoplasmic area above, under the two polar bodies; the yolk with the yolk globules below. In the protoplasm at the animal pole is seen the egg nucleus. The sperm nucleus is represented shortly after entering the lower half of the egg.

body" and is the larger of the two adherent bodies shown in Model 1,B.

This process of division of the nucleus is soon repeated, and a second smaller polar body is extruded. These two polar bodies remain in position for a considerable length of time. Although they do not take any part in the future development, becoming ultimately detached and lost, their elimination is of

particular significance in the preparation of the eggs for fertilization. The process is known as the "maturation" of the egg.

The sperm cells are inclosed with the ova in the capsules. They consist chiefly of a nucleus with a very insignificant amount of protoplasmic substance. A single sperm cell enters the ovum somewhere about the vegetative pole, at the time of the beginning of the maturation process, and its nucleus gradually makes its way upward toward the egg nucleus, until the two nuclei are in contact. These nuclei, known as the "pronuclei" of the egg, may be seen in Model 1,B lying close together in the protoplasm at the animal pole. The egg is now fertilized and capable of developing into a new organism.



MODEL 1, B

The fertilized egg, showing the egg and sperm nuclei in contact at the animal pole. On either side of them are the centrospheres.

Each nucleus is composed largely of a peculiar substance, which has been given the name "chromatin," because of the readiness with which it assumes the stains used for coloring microscopic objects. Though little is known about the definite function and properties of chromatin, its importance is evidently very great, for it is found in the nuclei of all cells. Generally it is

seen as small particles in the form of loops or bands, more or less compactly arranged, and of a definite number in any given species. To these the name "chromosomes" has been given. The division of a nucleus seems to consist mainly in a careful separation of the chromosomes into two equal parts.

There is also present in connection with each nucleus a small body which seems to be the center of all nuclear changes, the "centrosome." Whenever any activity of the nucleus such as a division takes place, the centrosome is in evidence.

Centrosomes are to be observed in both of the pronuclei of the undivided egg, and radiations apparently extend from them to each separate chromosome. The arrangement of the chromatin now becomes looser, and the chromosomes are more widely separated. The centrosomes come to lie in diametrically

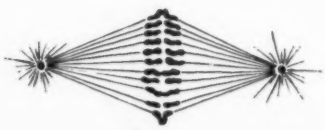


FIG. *c*

nuclear boundaries next disappear, the chromosomes become opposite positions with the two pronuclei between them. The

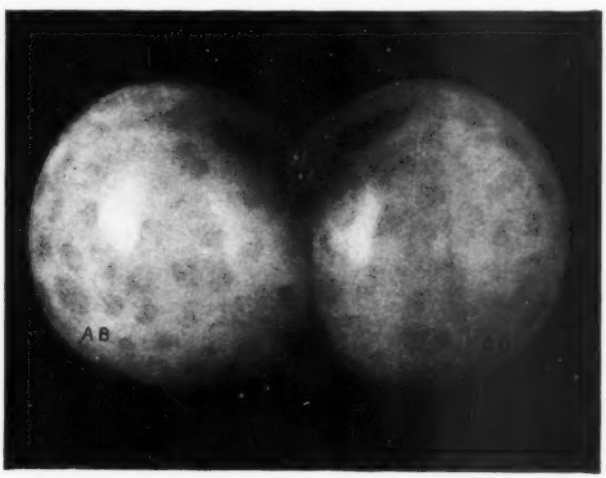
MODEL 2

First cleavage. Separation of chromosomes. Elongation and constriction of the egg preceding its complete division into two cells.

still farther separated, the radiations become more distinct, and soon seem to act on the chromosomes as two sets of fibers. The next step is a separation of every chromosome into two parts, which seem to be drawn in opposite directions toward the two centrosomes. These changes are shown in Model 2 and Fig. C.

In this manner two new nuclei are formed from the pronuclei, each new nucleus being composed of one-half of the chromatin of the male and female pronuclei, and each nucleus having a centrosome.

At the same time that the division of the pronuclei takes place a corresponding division of the whole egg occurs. The egg elongates (Model 2), a constriction takes place, and finally, coincident with the formation of the two new nuclei, there is

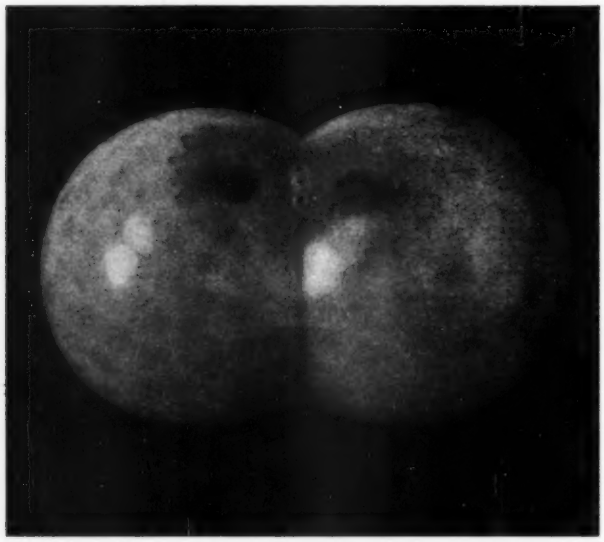


MODEL 3

Completion of first cleavage. Two cells. Polar bodies in the furrow between them. Daughter nuclei and centrospheres in each cell.

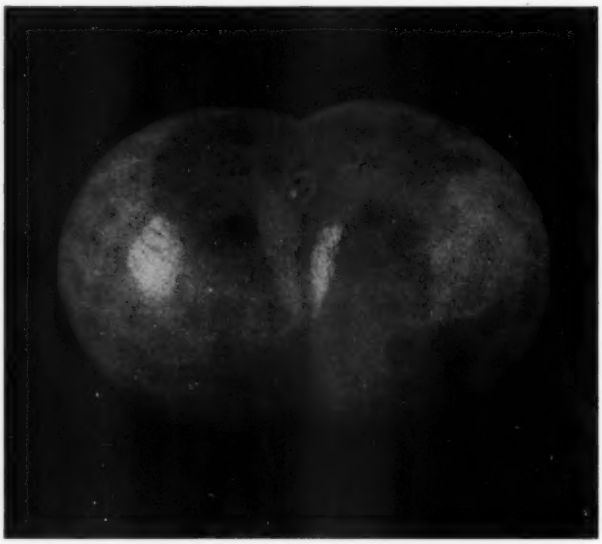
a complete separation of the egg into two halves, forming two new cells, each made up of protoplasm and yolk, like the single undivided egg, and each having a nucleus with its centrosome (Model 3). One of these two new cells gives rise to the anterior portion of the embryo, the other to the posterior.

Beginning with this, the first cleavage, up to the time when the larva is capable of taking in new food, the whole process of



MODEL 4

Resting stage after first cleavage. The two cells flattened against each other.



MODEL 5

Beginning of second cleavage. Nuclei resolved into division spindles. This model shows plainly two centrosomes, radiations and the two sets of chromosomes in each cell.

development proceeds through the repeated subdivision of these cells.

The second cleavage, which occurs at right angles to the first, divides the egg and the body of the future larva into right and left halves. This cleavage, initiated by a division of the centrosome, takes place by the changes in each nucleus, followed by an elongation and constriction of the cell. Finally a complete division of each nucleus and each cell into two parts takes place (Models 5 and 6). This gives four new cells, Model 7, each

MODEL 6

Second cleavage. Further separation of chromosomes. The two cells elongated and showing a constriction.

destined to form a definite part of the future organism, but each constituted as far as we can see in a precisely similar manner.

In the next, the third, cleavage the division takes place in a new direction. This, as indicated by the nuclear figures on Model 8, is oblique. Instead of a division into two equal parts, only a portion of the protoplasmic substance at the animal pole separates off, giving rise to four small cells which eventually lie above and slightly to the right of the four lower larger cells. (Model 9 shows the eight cells resulting from this cleavage.)

MODEL 7

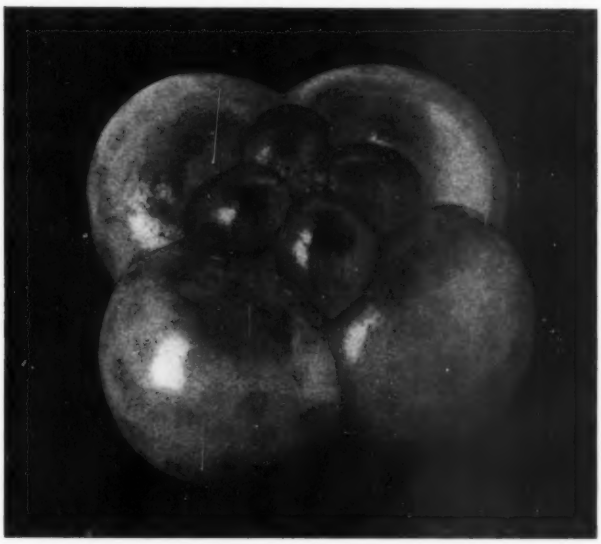
Second cleavage complete, so that four cells are formed.

MODEL 8

Third cleavage. Division spindles radial. The raised surface at the inner end of each spindle indicates the point at which four new cells will be separated off.

MODEL 9

Third cleavage completed. First quartet of small cells or ectoblasts formed.



MODEL 10

Fourth cleavage begun.

The fourth cleavage (Model 10) is also oblique. It results in the separation of another quartet of small protoplasmic cells slightly to the left of the large yolk-laden cells and also at the animal pole (Model 11).

The fifth cleavage is simply a division of the first quartet of small cells (Model 12).

By the sixth cleavage, the beginning of which is shown in Model 12, a third and last quartet of similar small cells is given off at the animal pole. This cleavage also is oblique, but to the right. By this alternation in the direction of each cleavage

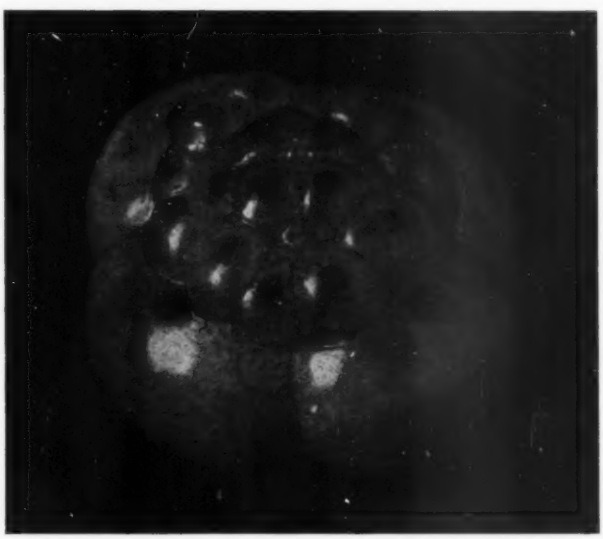
MODEL 11

Fourth cleavage completed. A second quartet of ectoblasts formed. Division beginning in cells of first quartet. Fifth cleavage begun.

plane, which began with first cleavage as indicated by the rotation of nuclei to the right, or in a clockwise direction on Model 4, the symmetrical arrangement of the cells is maintained. Lying at the animal pole of the egg, these three quartets of small cells form the so-called dorsal plate, which, by rapid multiplication of cells by division, is destined to grow until it completely covers the egg and forms the outer layer or ectoderm of the embryo. These cells are therefore known as "ectoblasts."

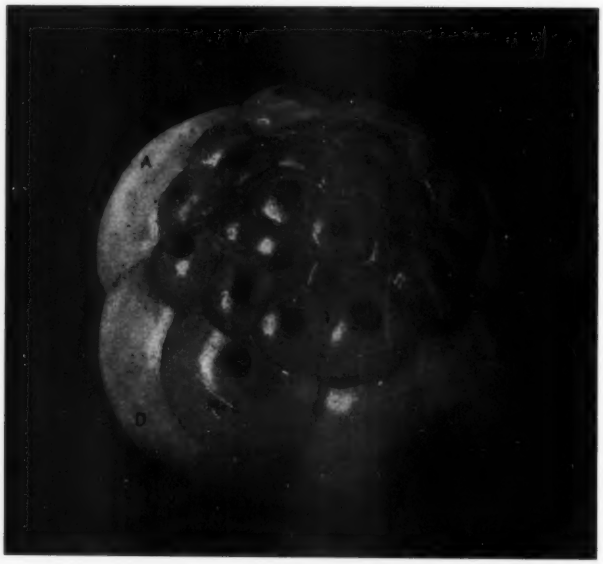
MODEL 12

Fifth cleavage completed. Sixth cleavage begun. Formation of third quartet of ectoblasts.



MODEL 13

Sixth cleavage completed. Second quartet has also divided; separation of ectoblasts completed.



MODEL 14

Separation from the left posterior large cell (D) of a single cell, the mesentoblast (M–E).

MODEL 15

Division of mesentoblast. The number of ectoblast cells has increased by further division of the three quartets.

The seventh cleavage (Model 12) divides the second quartet of ectoblasts.

The eighth cleavage (Model 13) consists of a second division of the first quartet of ectoblasts.

The ninth cleavage is unique, only one rather large cell, the "mesentoblast," M.-E. being separated off from the left posterior of the larger cells (D, Model 14). This new cell divides into two (Model 15) and again into four parts (Model 16). The upper two of these four cells, concealed on the model by the rim of the dorsal plate, multiply rapidly by division, and the cells which are formed from them make their way between the dorsal plate of the ectoblasts and the large yolk-laden cells below. They will form the future middle layer or mesoderm of the embryo, and

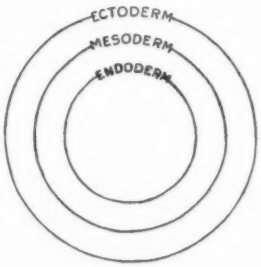


FIG. *d*

FIG. *e*

are known as the "mesoblasts." After the separation of the mesoblasts the remaining three large cells finally divide, giving in all eight or nine large inferior cells, the "entoblasts," which in time will form the inner layer of the embryo.

At an early stage there are thus separated in the egg the rudiments of the three layers distinguishable in the development of all higher animal organisms : ectoderm, mesoderm and entoderm. These may be diagrammatically represented as in Fig. *d*.

The ectoblasts by multiplication of cells soon extend over the entire ovum until only a narrow pore is left on the lower or ventral pole (Models 17, 18). Owing to the unequal rate of this growth, the upper or animal pole is at the same time shifted anteriorly till its angular distance from the lower vegetative pole becomes on this side only 90° (Model 18).

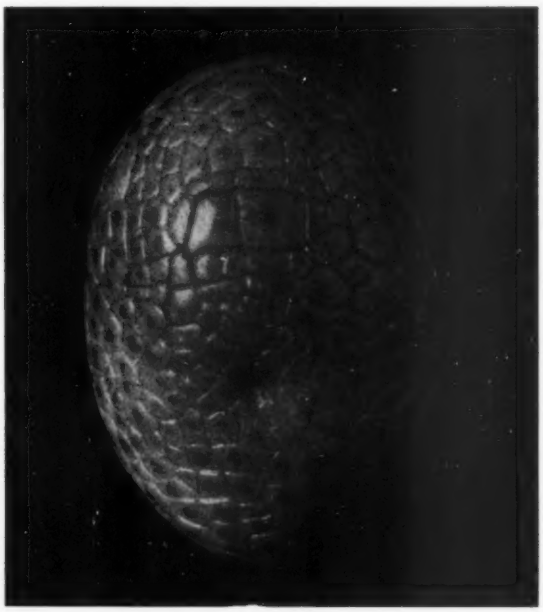
MODEL 16

Second division of mesentoblast, resulting in the formation of two mesoblasts and two entoblasts, which are concealed under the rim of the plate of ectoblasts, further divisions of ectoblast cell.

MODEL 17

Continued spreading of ectoblasts over the surface of the egg. Their origin from the three quartets is indicated in the model by colors: first quartet, red; second, blue; third, uncolored.

Immediately around the pore left by the closing of the edge of the ectoblasts is seen on this model the depression which indicates the beginning of the future mouth of the embryo. For a short time the pore itself is closed, but soon opens again and communication is thus established between the exterior and the internal cavity of the embryo. The structure of the embryo at this time may be represented diagrammatically as in Fig. *e*.



MODEL 18

The ectoblasts completely enclose the egg, leaving only a narrow pore (blastopore), about which is seen a depression. The derivation of ectoblasts from the three quartets indicated on the models by the coloring. The various regions of the future larva are becoming more sharply defined.

From this time on, the development consists of the differentiation by growth of the multiplying cells of these three separate layers into the specialized organs of the body.

The ectoderm cells which, as shown by the number of nuclei, are already very numerous, multiply rapidly in certain areas indicated by the slight outgrowths on the surface. These soon become more pronounced and form the beginning of the ectodermic organs of the embryo.

Above the mouth opening, which by this time is clearly defined, a ridge marks the beginning of the velum, or swimming organ, of the larva; below the mouth there is a large protuberance which will form the foot; at the sides of this two smaller knob-like outgrowths form the larval kidneys. At a point directly op-

MODEL 19

The larva begins to assume its definitive form. The mouth opening is formed; above it the curved edge of the velum is defined; below it the foot begins to protrude; on either side of this the first appearance of the larva kidney (EX) is indicated. At the lower pole of the model the shell gland is shown.

posite the apical, or head, end the shell gland develops (Model 18). Model 19 shows the shell beginning to be secreted by the shell gland.

The entoblast cells of the cavity of the gastrula by a process of unequal growth rapidly go to form the various parts of the digestive tube: stomach, liver, intestine etc. The œsophagus is formed by an invagination of the ectoderm from the exterior.

The middle layer, the mesoblastic layer, forms the muscles,

the circulatory system, heart and blood-vessels and the supporting tissues of the body.

Coincident with this differentiation of the regions of the body into organs, a change in the direction of the antero-posterior axis of the embryo takes place. The whole posterior portion is

MODEL 20

The formation of the veliger larva has proceeded farther. The various external organs are well defined. Below is seen the shell secreted by the underlying cells of the shell gland.

pushed ventrally: the mouth opening and the whole apical pole are shifted forward, and there is a twisting of the entire axis, plainly seen in the bending of the intestine. This organ, which originally lay in the mid-ventral line, assumes the form of an almost complete loop (Model 22). The asymmetry of the

mollusk larva is thus established and the definitive asymmetry of the adult is foreshadowed.

Models 21 and 22 show the completed larva, the free-swim-

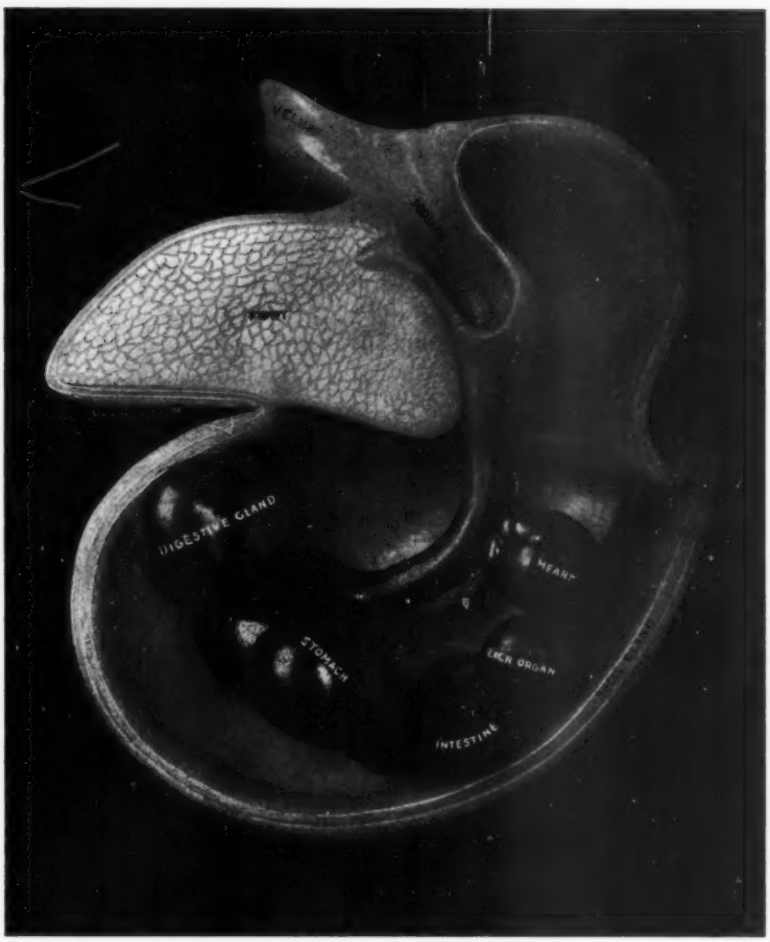
MODEL 21. SIDE VIEW

The mollusk larva, or the veliger, completed. The velum, or swimming organ, about the anterior end bears two rows of cilia. The foot is large and prominent and bears on its under surface the lid, or operculum, by which the opening of the shell is closed when the animal withdraws into it. On the head are seen the two eyes. The two raised points near these mark the position of the feelers or tentacles.

ming veliger with its fully formed ciliated velum, or swimming organ, the shell and the large foot, bearing on its lower surface the operculum, or lid, by means of which the shell is closed when

the animal withdraws into it. On the head are seen the two eyes and near them the tentacles.

The veliger stage, though more or less suppressed in land mollusks, is common to all gastropods. By an additional series of changes, consisting in a continued growth and development in certain directions, this larva is ultimately metamorphosed into the adult form of its species.



MODEL 22

A section of the veliger showing the internal anatomy.

APPENDIX.

TECHNICAL DESCRIPTION OF THE MODELS.[1]

1. A. The ovum of *Crepidula* at the time of fertilization.

1. B. The fertilized ovum showing pronuclei lying in the cytoplasm at the animal pole. On either side of them the centrospheres. At the vegetative poles is seen the yolk-stalk. Jour. Morph., Vol. XIII, 1897, fig. 1.

2. First cleavage—appearance of first cleavage furrow. Jour. Morph., Vol. XIII, figs. 3, 4.

3. Completion of first cleavage furrow. Nuclei and asters opposite each other in the two blastomeres. Between the blastomeres are the polar bodies. Jour. Morph., Vol. XIII, fig. 5.

4. Resting stage after first cleavage. Flattening of blastomeres against each other. Dexiotropic turning of nuclei, asters and protoplasmic areas. Jour. Morph., Vol. XIII, fig. 7.

5. Beginning of second cleavage. Læotropic turning of spindles and protoplasmic areas. The centrospheres of preceding cleavage lie near the cleavage furrow. Jour. Morph., Vol. XIII, fig. 7.

6. Second cleavage. Beginning of second cleavage furrow. Læotropic rotation of spindles. Polar furrow being formed. Jour. Morph., Vol. XIII, fig. 9.

7. Completion of second cleavage. Asters nearly in position of poles of preceding spindles. Polar furrow well formed. Jour. Morph., Vol. XIII, fig. 10.

8. Third cleavage. Spindles almost radial, but showing slight dexiotropic rotation. Jour. Morph., Vol. XIII, fig. 12.

9. Third cleavage. Completion of first quartet. Position of asters shows that division was dexiotropic. Jour. Morph., Vol. XIII, fig. 13.

10. Fourth cleavage. Læotropic. First quartet has rotated into furrows between macromeres. Jour. Morph., Vol. XIII, fig. 14.

11. Fourth cleavage complete. Fifth cleavage, læotropic division of first quartet of micromeres and formation of "turret cells" (trochoblasts). Jour. Morph., Vol. XIII, fig. 16.

12. Fifth cleavage complete. Sixth cleavage dexiotropic. Formation of third and last quartet of ectomeres. Sixteen cells. Jour. Morph., Vol. XIII, fig. 17.

[1] The models correspond to the figures in "The Development of Crepidula," by Dr. E. G. Conklin, Jour. Morph., Vol. XIII, 1897, and "Karyokinesis and Cytokinesis," Jour. Acad. Nat. Sci., 2d Ser., Vol. XII, Phila., 1902.

13. Sixth cleavage complete. Division of second quartet complete. Quadrangular plate of ectomeres with angles of plate in furrows between macromeres. Twenty ectomeres (4 apical, 4 turret and 12 belt cells) and 4 macromeres. Jour. Morph., Vol. XIII, figs. 19, 20.

14. Formation of first member of fourth quartet, the mesentoblast, from the left posterior macromere; formation of basal cells of cross by the second division of first quartet. Jour. Morph., Vol. XIII, figs. 22, 23.

15. Division of the mesentoblast completed, dexiotropic. Second and third quartets. Turret cells formed. Forty-two cells: 4 apicals 8 cross, 4 turret, 20 belt cells, 2 mesentoblasts, 4 macromeres. Jour. Morph., Vol. XIII, fig. 29.

16. Fourth quartet completed by læotropic cleavage of macromeres, A, B and C. The two mesentoblasts of the preceding stage have divided, forming the two enteroblasts and two primary mesoblasts which lie immediately above the latter, but concealed by the plate of ectoblasts. Jour. Morph., Vol. XIII, fig. 31.

17. Further division of ectoblasts. Expansion of arms a, b and c of ectoblastic cross into a cell plate. Anterior shifting of apical cells. Posterior turret cells undivided. Formation of quadrangular blastopores, the enteroblasts in posterior angle. Jour. Morph., Vol. XIII, figs. 51, 52.

18. Later stage. Apex on ventral side, slightly to the right. Cells of ectoblastic cross, first quartet, cover the whole anterior end of embryo. Large cells of posterior arm, dorsal. The closing of the blastopore and a depression about it indicating the formation of the stomodæum. The superior rows of ectoblast cells of second quartet, directly above the blastopore, form the first and second velar rows. The shell gland is forming at the postero-dorsal and somewhat to the left. Jour. Morph., Vol. XIII, figs. 65, 74, 75.

19. Older embryo, showing apical, posterior and pedal cell plates. On either side to the anterior and posterior of the dorsal cell plate, the velar rows are branching. Mouth and the external kidneys are formed, the shell gland expanding. Jour. Morph., Vol. XIII, figs. 76 to 79.

20. Older stage-formation of velum and foot. The shell gland greatly expanded and forming the shell of the veliger. Jour. Morph., Vol. XIII, figs. 80–82.

21. The fully formed veliger.

22. Section of the preceding.

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